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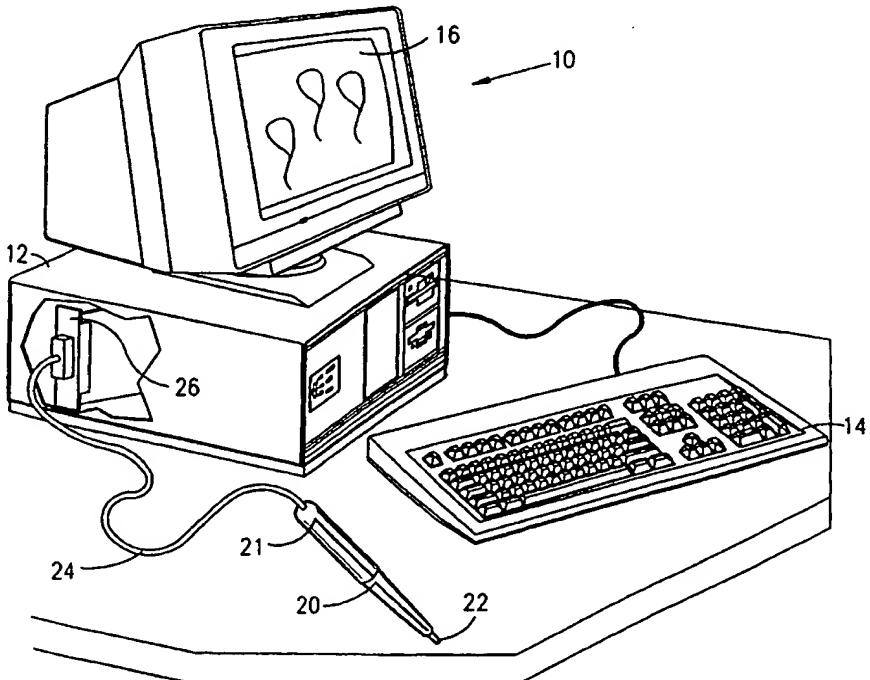
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**(54) Title:** DISPLAY POINTING DEVICE

**(57) Abstract**

This invention discloses a display pointing device (20) comprising a housing (21), an optical sensor mounted in the housing (21), and processing circuitry receiving an output from the optical sensor for identifying a location on a display (16) pointed to by the pointing device (20) based on the optically sensible characteristics of at least one pattern at the location which is sensed by the optical sensor. A method of operating the display pointing system (10) is also disclosed.



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## DISPLAY POINTING DEVICE

### FIELD OF THE INVENTION

The present invention relates to display pointers which can be used to indicate location on a display, such as a computer display.

### BACKGROUND OF THE INVENTION

Various types of display pointers are known in the art. These include devices such as "light pens" or toy firing devices which can be pointed at or brought into propinquity with a given location on a display, such as a CRT display, for sensing illumination features thereof. Conventional light pens of this type require relatively complex synchronization circuitry for determining location on the display based on the time relationship of sensed illumination and of the time base of the display, including its synchronization pulses.

Prior art pointers of the type described hereinabove often require feedback in order to achieve location sensing. In practice a sensor on the pointer feeds back a signal that it sensed on the screen to a timing circuit in a computer. The timing circuit determines the time relationship of the sensed signal to the vertical and horizontal video synchronization signals of the screen and thus determines the position of the pointer on the screen.

The current state of the art is believed to be represented by the following U.S. Patents: 5,187,467; 5,184,115; 5,119,075; 4,608,601; 4,602,907; 4,190,851; 3,944,988; 3,832,693; 3,758,717; 3,659,281; 3,594,608; 3,576,574; 3,551,896; 3,543,240; 3,506,875; 3,505,561; 5,572,251; 5,138,304; 5,134,389; 5,051,736; 4,956,639; 4,922,236; 4,675,665; 4,591,841; 4,377,810 & 4,367,465.

### SUMMARY OF THE INVENTION

The present invention seeks to provide an improved, relatively low cost display pointing device having multiple and varied applications.

There is thus provided in accordance with a preferred embodiment of the present invention a display pointing device including:

- a housing;
- an optical sensor mounted in the housing; and

processing circuitry receiving an output from the optical sensor for identifying a location on a display pointed to by the pointing device based on the optically sensible characteristics of at least one pattern sensed by the optical sensor.

There is also provided in accordance with a preferred embodiment of the present invention a display pointing method including:

pointing an optical sensor mounted in the housing at a location on a display;

receiving an output from the optical sensor; and

identifying a location on the display pointed to by the pointing device based on the optically sensible characteristics of at least one pattern sensed by the optical sensor.

In accordance with one embodiment of the present invention, the processing circuitry determines a location on the display pointed to by the pointing device based on the optically sensible characteristics of a plurality of patterns, which are seen sequentially by the optical sensor and which are optically distinguishable from each other.

The at least one pattern may or may not be superimposed on a displayed image, as by eliminating lines in a displayed image. The at least one pattern may cover the entire display or only parts thereof.

The processing circuitry may employ pattern recognition circuitry which may be hard wired or embodied, wholly or partly in software.

The pointer may be used with a CRT display or alternatively with other types of display such as liquid crystal displays.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Fig. 1 is a simplified illustration of a CRT pointing system constructed and operative in accordance with a preferred embodiment of the present invention;

Figs. 2A, 2B and 2C illustrate the operation of a CRT pointing system of Fig. 1;

Figs. 3A, 3B, 3C, 3D and 3E are illustrations of five coded patterns employed in the system of Figs. 2A - 2C and corresponding pulse trains sensed by a pointer viewing such patterns;

Fig. 4 is a simplified sectional illustration of a preferred pointer constructed and operative in accordance with a preferred embodiment of the present invention;

Figs. 5A and 5B together are an electrical schematic illustration of a preferred embodiment of the pointer of Fig. 4;

Fig. 6 is a simplified illustration of a CRT pointing system constructed and operative in accordance with another preferred embodiment of the present invention;

Figs. 7A, 7B, 7C, 7D and 7E illustrate the operation of a CRT pointing system of Fig. 6;

Fig. 8 is a timing diagram related to the operation of the embodiment of Figs. 6 - 7E;

Fig. 9 is a simplified illustration of a CRT pointing system constructed and operative in accordance with still another preferred embodiment of the present invention;

Figs. 10A, 10B, 10C and 10D illustrate the operation of a CRT pointing system of Fig. 9;

Figs. 11A, 11B and 11C illustrate the operation of the embodiment of Figs. 9 - 10D;

Fig. 12 is a simplified illustration of a CRT pointing system constructed and operative in accordance with yet another preferred embodiment of the present invention;

Fig. 13 is an illustration of the structure of the field of view of a trackable cursor employed in the system of Fig. 12;

Figs. 14A and 14B are together a flowchart illustrating the operation of the system of Figs. 12 and 13; and

Fig. 15 is an illustration of apparatus for remote pointing in accordance with an embodiment of the present invention.

## LIST OF APPENDICES

Appendix 1 is listing of software embodied in a microcontroller forming part of the circuitry of Fig. 5B;

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Reference is now made to Fig. 1, which is a simplified illustration of a CRT pointing system constructed and operative in accordance with a preferred embodiment of the present invention. The system comprises a conventional computer 10 including a circuit board housing 12, a keyboard 14 and a display 16, such as a CRT display. In accordance with a preferred embodiment of the present invention, there is additionally provided a pointer 20 which can be used to point to a given location on the display 16, as figuratively illustrated in Fig. 2A.

In accordance with a preferred embodiment of the present invention, the pointer 20 includes a hand held housing 21 within which is disposed an optical sensor which is preferably located at a tip 22 thereof. The optical sensor is coupled by a wire 24 or alternatively in a wireless manner to processing circuitry which may be located within the housing 21 or alternatively in a circuit board 26 located within circuit board housing 12.

Figs. 2A, 2B and 2C illustrate the operation of the CRT pointing system of Fig. 1 in accordance with one embodiment of the present invention in the context of a simple game in which the user bursts balloons by pointing at them. The user normally sees what is illustrated in Fig. 2A, however, in accordance with a preferred embodiment of the invention, intermittently and for a duration which preferably is so short that it cannot be seen by the user, each of the balloons is indicated by a differing pattern, as seen in Fig. 2B. This pattern is sensed by the optical sensor in the pointer 20 and is recognized by the processing circuitry downstream thereof. Once a given pattern corresponding to a given balloon is recognized, the processing circuitry provides an output indication which causes a burst balloon image to appear on the display, as illustrated in Fig. 2C.

Reference is now made to Figs. 3A, 3B, 3C, 3D and 3E, which are illustrations of five coded patterns employed in the system of Figs. 2A - 2C and corresponding pulse trains sensed by a pointer viewing such patterns. Fig. 3A illustrates a

blank screen which contains all scan lines, while Figs. 3B, 3C, 3D and 3E illustrate the patterns of balloons which are indicated by respective reference numerals 30, 32, 34 and 36 in Fig. 2B. It is to be appreciated that preferably, the optical sensor senses the pulse train corresponding to each of the patterns without requiring synchronization with the vertical and horizontal synchronization pulses employed by the display.

Reference is now made to Fig. 4, which is a simplified sectional illustration of a preferred pressure-actuated pointer 20 constructed and operative in accordance with a preferred embodiment of the present invention. The pointer preferably comprises a housing 40 having a spring biased retractable tip 42 in which is disposed an optical sensor 44, such as a Motorola MRD 3056 phototransistor.

Retraction of tip 42 against the urging of a spring 46 is operative to close a switch, shown schematically at reference numeral 48. The output of optical sensor 44 is preferably supplied to processing circuitry located on a printed circuit board 50 which communicates via a cable 52 and a connector 54 with suitable circuitry within circuit board housing 12 (Fig. 1).

Reference is now made to Figs. 5A and 5B, which together are an electrical schematic illustration of a preferred embodiment of the pointer of Fig. 4. It is seen that the optical sensor 44 is preferably a phototransistor such as an MRD 3056 which outputs via an amplification circuit to a signal processing circuit U1, such as a PIC16CR54RC-P microcontroller. The signal processing circuit is in turn coupled to connector 54, which is typically a DB15 connector which interfaces with a conventional game port of any suitable PC computer.

Reference is now made to Fig. 6, which is a simplified illustration of a CRT pointing system constructed and operative in accordance with another preferred embodiment of the present invention. In this embodiment, rather than sensing a pattern, the optical sensor and associated processing circuitry senses a series of sequential patterns, the combination of which indicated a particular location on the display 116.

Referring now to Figs. 7A, 7B, 7C, 7D and 7E and the timing diagram of Fig. 8, it can be seen that while the user sees the display shown in Fig. 7A, in accordance with a preferred embodiment of the invention, and as distinguished from the embodiment of Figs. 2A - 3F, sequentially and over a duration which preferably is so short that it

cannot be seen by the user, each of the patterns of Figs. 7B, 7C, and 7D appears on the display at least on the portion of the display which the pointer is pointing to.

The sequence of patterns sensed by the optical sensor in the pointer 20 and is recognized by the processing circuitry downstream thereof. Once a given pattern sequence corresponding to a given location is recognized, the processing circuitry provides an output indication which causes an illuminated symbol to appear on the display at the given location, as illustrated in Fig. 7E.

Fig. 8 illustrates the identity of the pattern which is sensed by the optical sensor, aimed at the black pawn, at various times. Thus at time T1, which corresponds to Fig. 7A, no pattern is sensed. At time T2, pattern C (Fig. 7B) is sensed. At time T3, pattern D (Fig. 7C) is sensed, at time T4, pattern B (Fig. 7D) is sensed and at time T5, no pattern is sensed, as indicated in Fig. 7E.

Reference is now made to Fig. 9, which is a simplified illustration of a CRT pointing system constructed and operative in accordance with still another preferred embodiment of the present invention. A standard computer application is shown on the display screen 116.

Referring additionally to Figs. 10A, 10B, 10C and 10D it is seen that in contrast to the pointing systems described hereinabove, wherein each region has a unique pattern or patterns which is not sensitive to pen position within the region, here highly accurate vertical position sensing is provided.

Fig. 10A shows the screen 116 that is normally viewed by the user, while Figs. 10B and 10C illustrate sequential patterns 120, 122 which appear on the display screen 116 to provide position determination. The pattern 120 of Fig. 10B is a series of vertical lines which enable vertical position therealong to be sensed unambiguously, while the pattern 122 of Fig. 10C is a pattern which enables horizontal position to be sensed, albeit to a lesser degree of resolution than that realized for the vertical position. Fig. 10D illustrates the appearance of display screen 116 when the pointer is pointing at the "4" key.

The pattern of Fig. 11A is a particularly useful arrangement of lines for unambiguously indicating vertical position, it being understood that various other arrangements may be employed. The pattern of Fig. 11A is built of pairs of illuminated

horizontal lines, each indicated by an asterix, separated by typically six lines which may or may not be illuminated in accordance with a given binary code. The six horizontal lines thus provide 64 different coded combinations.

In order to minimize ambiguity, the pattern of Fig. 11A employs successive inversely coded arrangements. Thus the first group of six horizontal lines represents the binary number "5" and the successive group of six horizontal lines represents the binary number "58". The next group of six horizontal lines represents the binary number 6, and the next successive group of six horizontal lines represents the binary number "57".

Reference is now made to Figs. 11A, 11B and 11C, which illustrate the operation of the embodiment of Figs. 9 - 10D. Fig. 11A shows a portion of the pattern of Fig. 10B and indicates, at reference numeral 80, a portion of the pattern which can be seen by a pointer 20 at a given pointer position.

Fig. 11B indicates the code sequence sensed by the pointer 20 viewing the pattern portion indicated by reference numeral 80, while Fig. 11C indicates the code sequence sensed by the pointer 20 viewing a pattern portion indicated by a reference numeral 82.

It may be appreciated from a consideration of Figs. 11B and 11C that the coarse position of the pointer is determined by the identity of the coded 6-line pattern, while the precise position of the pointer is determined by counting the number of scan lines between the extreme illuminated scan lines that are sensed by the optical sensor. This indicates the extent of the field of view of the optical sensor. By dividing this number in half, the center of the field of view is determined and thus the precise position of the pointer is determined. The center of the field of view of the pointer is indicated as Y1 and Y2 respectively in Figs. 11B and 11C.

Once the precise vertical position of the pointer is determined, the horizontal position is determined by means of sensing the patterns shown in Fig. 10C, using the techniques described hereinabove with reference to Figs. 2B - 3E.

Reference is now made to Fig. 12, which is a simplified illustration of a CRT pointing system constructed and operative in accordance with yet another preferred embodiment of the present invention. The pointing system of Fig. 12 is particularly

suitable for "drawing" on a display screen 100, using a pointer 102. The CRT pointing system of Fig. 12 preferably employs a multi-patterned trackable cursor dot 110, such as that shown in Fig. 13.

Fig. 13 illustrates the structure of the trackable cursor 110 employed in the system of Fig. 12, showing preferably nine different sensing regions, each bearing a different pattern, which pattern can be distinguished one from the other by an optical sensor (not shown) in pointer 102 or by downstream circuitry associated therewith.

Figs. 14A and 14B are together a flowchart illustrating the operation of the system of Figs. 12 and 13. When the pointer 102 is directed at one of the regions of the cursor dot 110 of Fig. 13, the pattern read by the optical sensor indicates the direction of intended movement of the cursor dot. Thus, as indicated in Figs. 14A and 14B, if the sensed pattern is the C or central pattern, the X and Y positions of the cursor dot are not changed.

If however, the optical sensor senses the pattern "N", the cursor is displaced upwardly in the next frame. Similar cursor displacements are indicated by sensing the patterns "S", "E", "W", "NW", "NE", "SW" and "SE", as indicated in Figs. 14A and 14B.

Reference is now made to Fig. 15, which is an illustration of apparatus for remote pointing in accordance with an embodiment of the present invention. The pointer of Fig. 15 typically comprises a generally gun-shaped housing 140 having a lens 142 at the front thereof for viewing a given location on a display screen 143. An optical sensor 144, such as a Motorola MRD3056 phototransistor, is provided at the focal plane of lens 142. A trigger 146 is operative to close a switch, shown schematically at reference numeral 148. The output of optical sensor 144 is preferably supplied to processing circuitry located on a printed circuit board 150 which communicates via a cable 152 or alternatively in a wireless manner, and a connector 154 with suitable circuitry within circuit board housing 12 (Fig. 1).

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove but rather extends to equivalents of the structures and features described and shown as

well as to various combinations and subcombinations of those feature which are not known or obvious from the prior art.

## APPENDIX 1

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// Light Pen HEX Module
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```
:100000000400280067000400E702030A302030A6C
:10001000008070C2600040065061A0A0000000000C
:1000200000000000000000000000000000000000000E702E7
:100030000B0A0706DD09280028024307C10A070246
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:00000001FF
```

## C L A I M S

1. A display pointing device comprising:
  - a housing;
  - an optical sensor mounted in the housing; and
  - processing circuitry receiving an output from the optical sensor for identifying a location on a display pointed to by the pointing device based on the optically sensible characteristics of at least one pattern at said location which is sensed by the optical sensor.
2. A device according to claim 1 and wherein said processing circuitry identifies the location on the display pointed to by the pointing device based on the optically sensible characteristics of a plurality of patterns, which are seen sequentially by the optical sensor and which are optically distinguishable from each other.
3. A device according to either of the preceding claims and wherein said at least one pattern is superimposed on a displayed image.
4. A device according to any of the preceding claims and wherein said at least one pattern is superimposed on a displayed image by eliminating lines in said displayed image.
5. A device according to any of the preceding claims and wherein said at least one pattern covers generally an entire screen of said display.
6. A device according to any of the preceding claims 1 - 4 and wherein said at least one pattern covers parts of a screen of said display.
7. A device according to any of the preceding claims and wherein said processing circuitry employs pattern recognition circuitry.

8. A device according to any of the preceding claims and also comprising a display.
9. A device according to claim 8 and wherein said display is a CRT display.
10. A device according to claim 8 and wherein said display is a liquid crystal display.
11. A display pointing method including:  
pointing an optical sensor mounted in the housing at a location on a display;  
receiving an output from the optical sensor; and  
identifying a location on the display pointed to by the pointing device based on the optically sensible characteristics of at least one pattern sensed by the optical sensor.
12. A method according to claim 11 and wherein said step of identifying a location employs optically sensible characteristics of a plurality of patterns, which are seen sequentially by the optical sensor and which are optically distinguishable from each other.
13. A method according to either of the preceding claims 11 and 12 and wherein said at least one pattern is superimposed on a displayed image.
14. A method according to any of the preceding claims 11 - 13 and wherein said at least one pattern is superimposed on a displayed pattern by eliminating lines in said displayed image.
15. A method according to any of the preceding claims 11 - 14 and wherein said at least one pattern covers generally an entire screen of said display.

16. A method according to any of the preceding claims 11 - 14 and wherein said at least one pattern covers parts of a screen of said display.

17. A method according to any of the preceding claims 11 - 16 and wherein the determination step employs pattern recognition.

18. A method system according to any of the preceding claims 11 - 17 and wherein said optical sensor views a CRT display.

19. A method according to any of the preceding claims 11 - 17 and wherein said optical sensor views a liquid crystal display.

20. A method according to claim 17 and wherein said pattern recognition employs an unambiguous pattern of scan lines.

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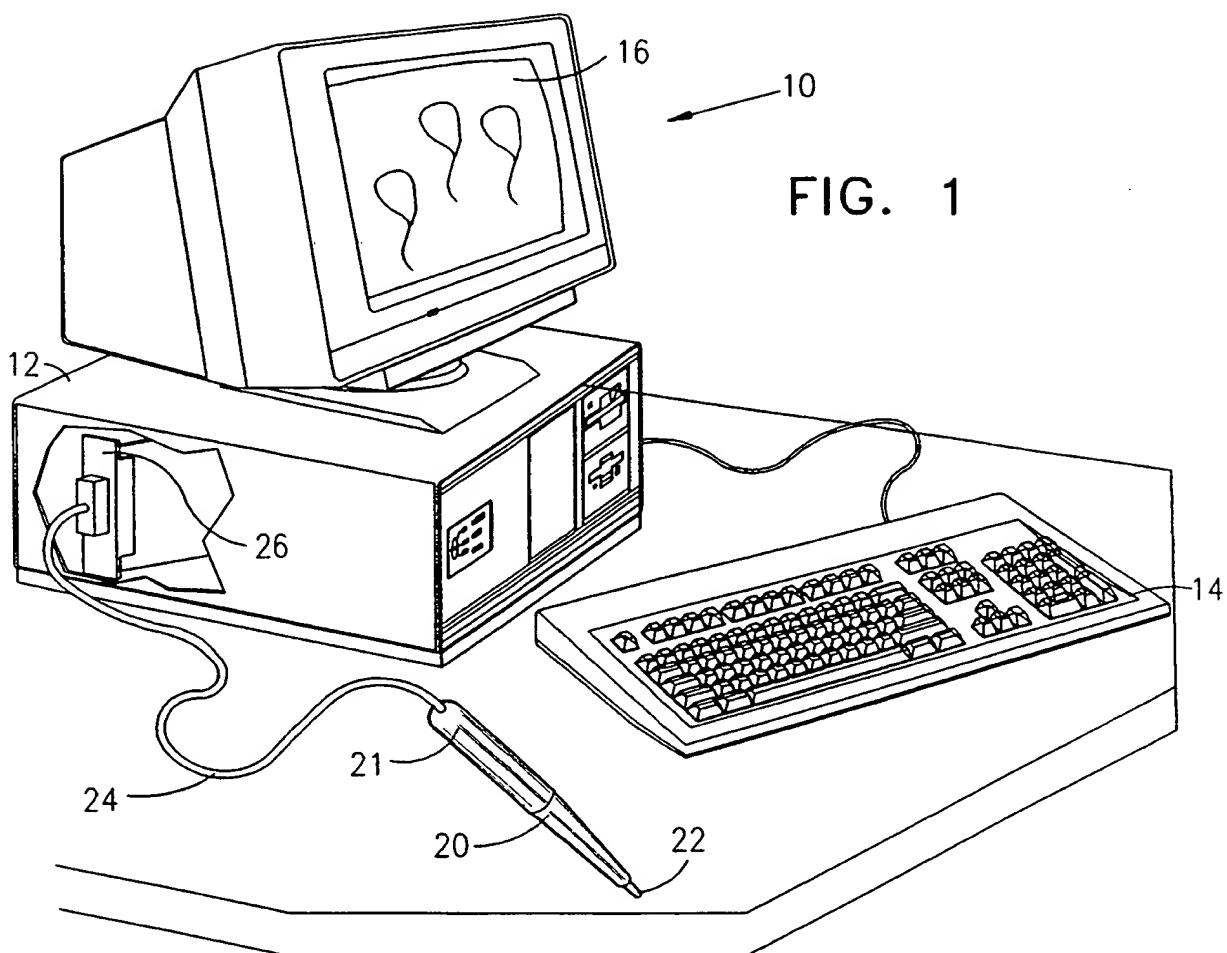
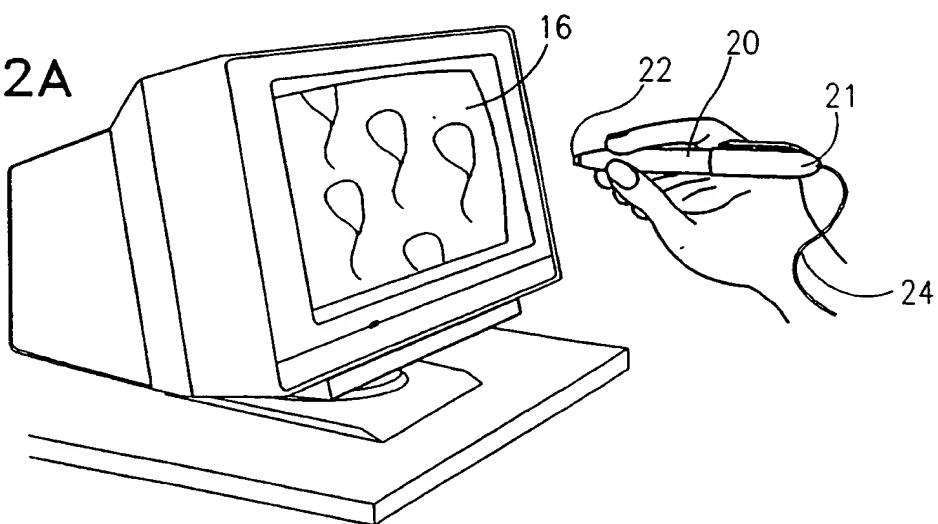


FIG. 2A



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FIG. 2B

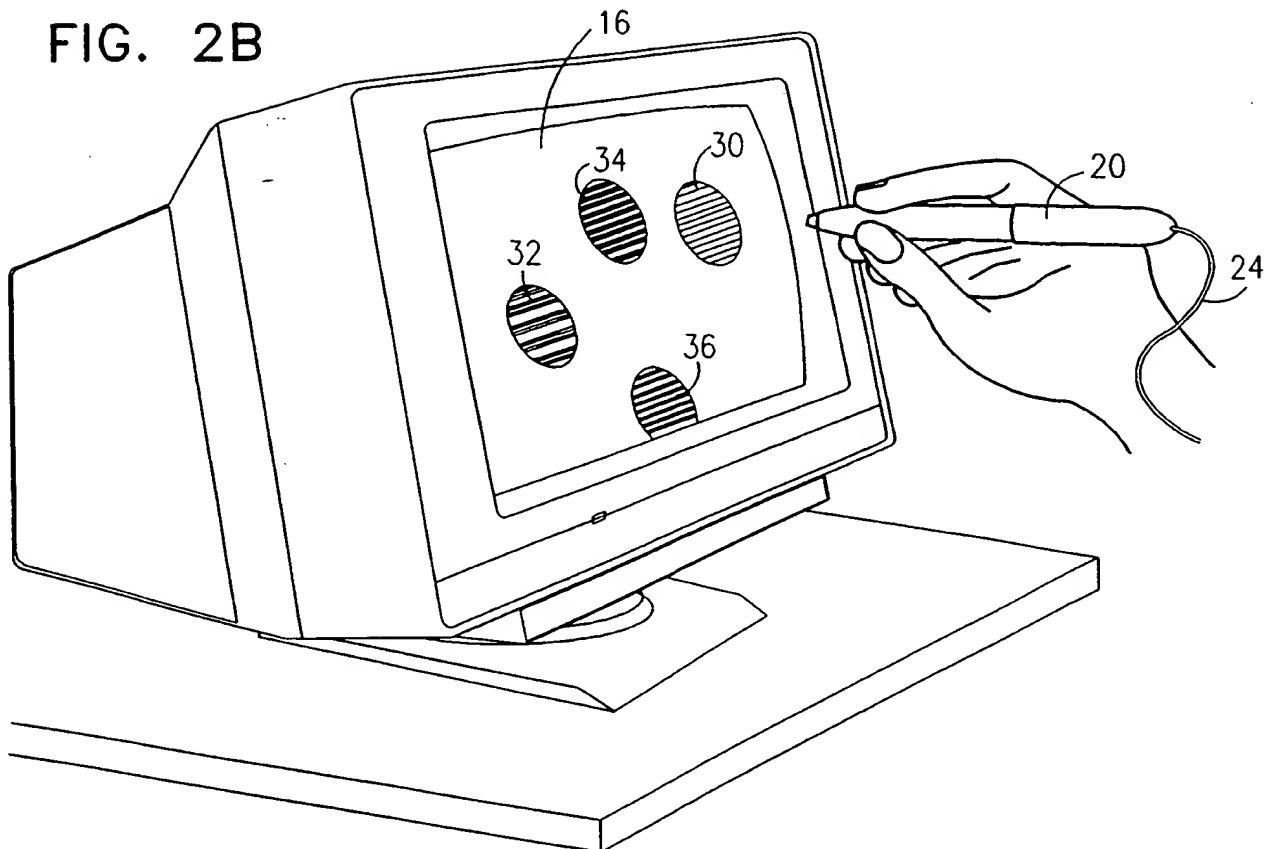
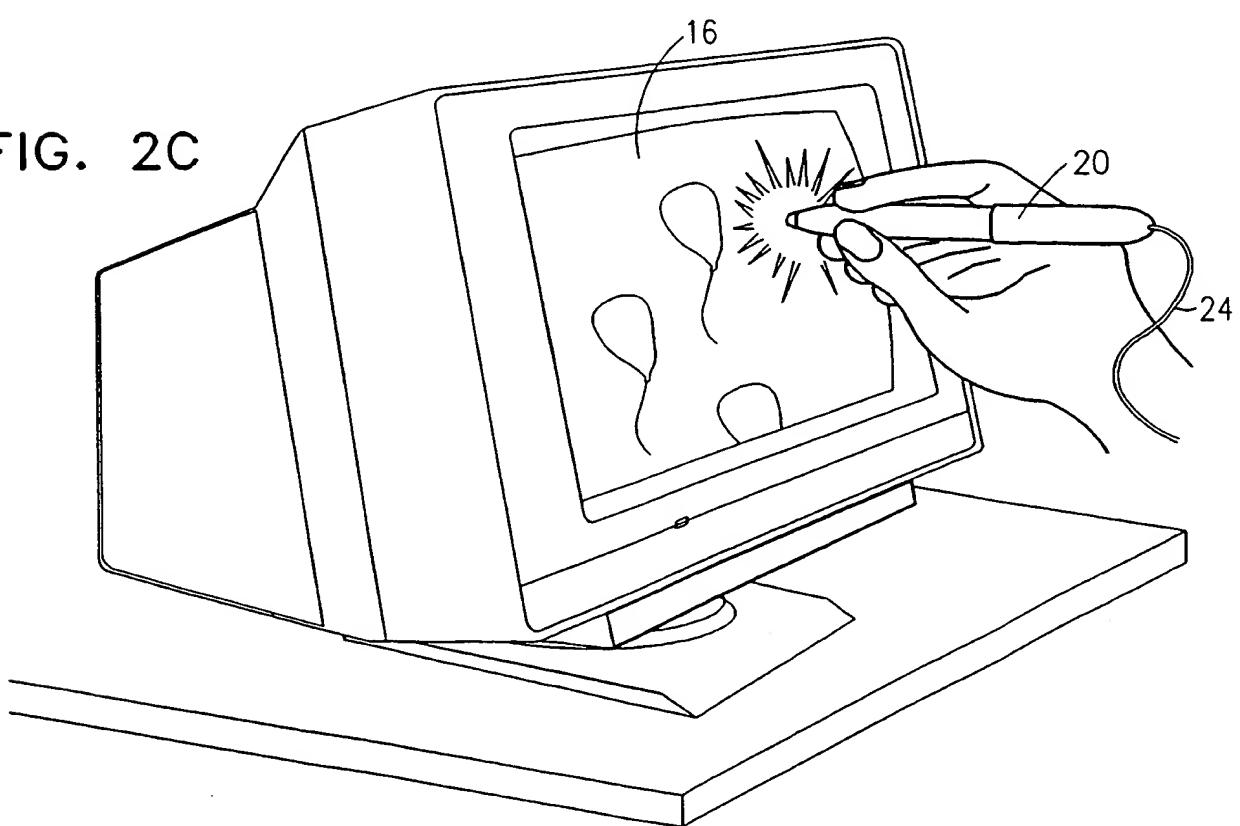


FIG. 2C



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FIG. 3A

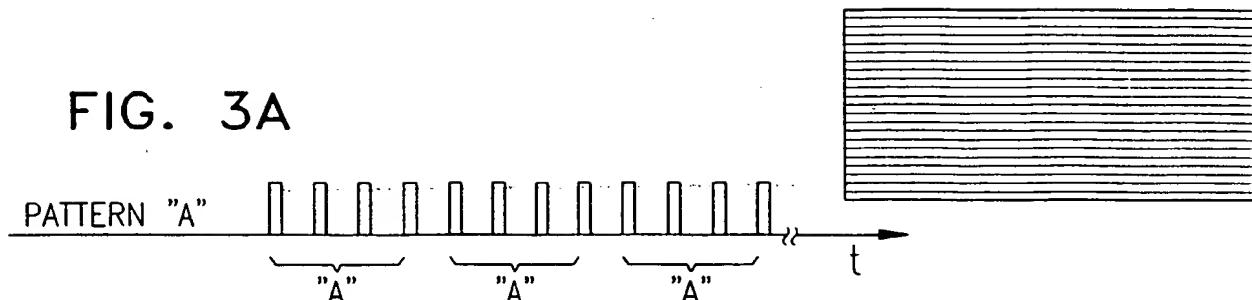


FIG. 3B

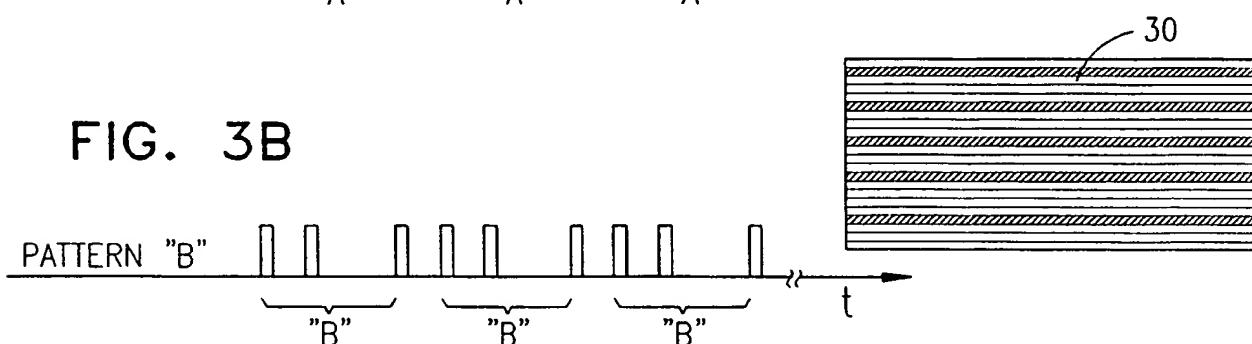


FIG. 3C

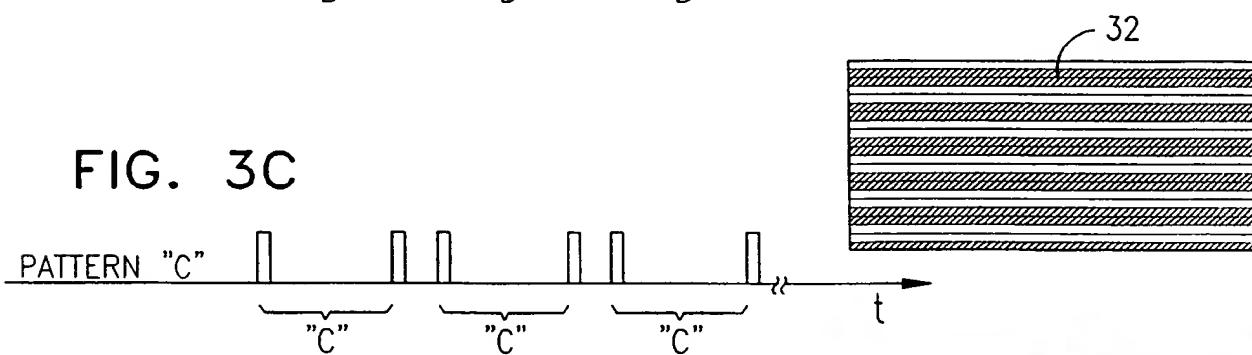


FIG. 3D

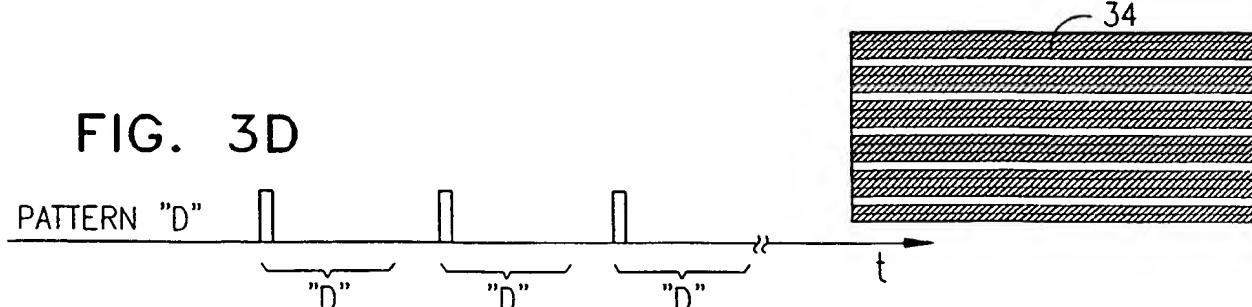
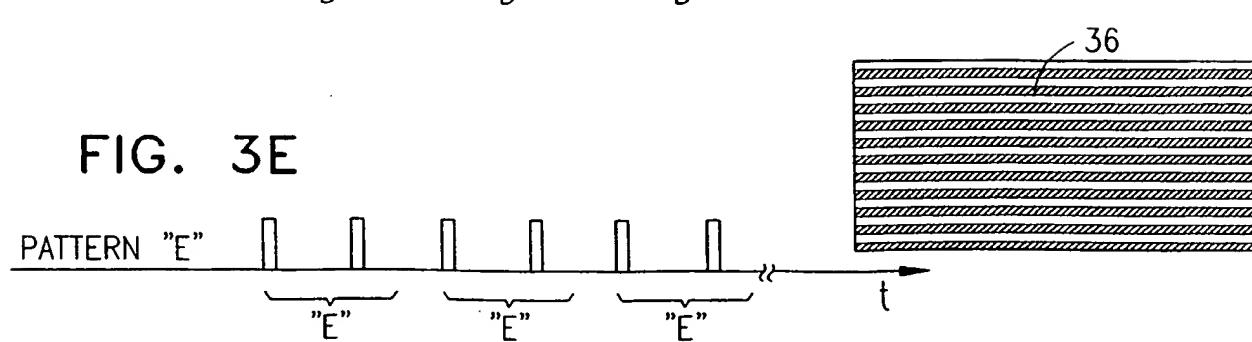
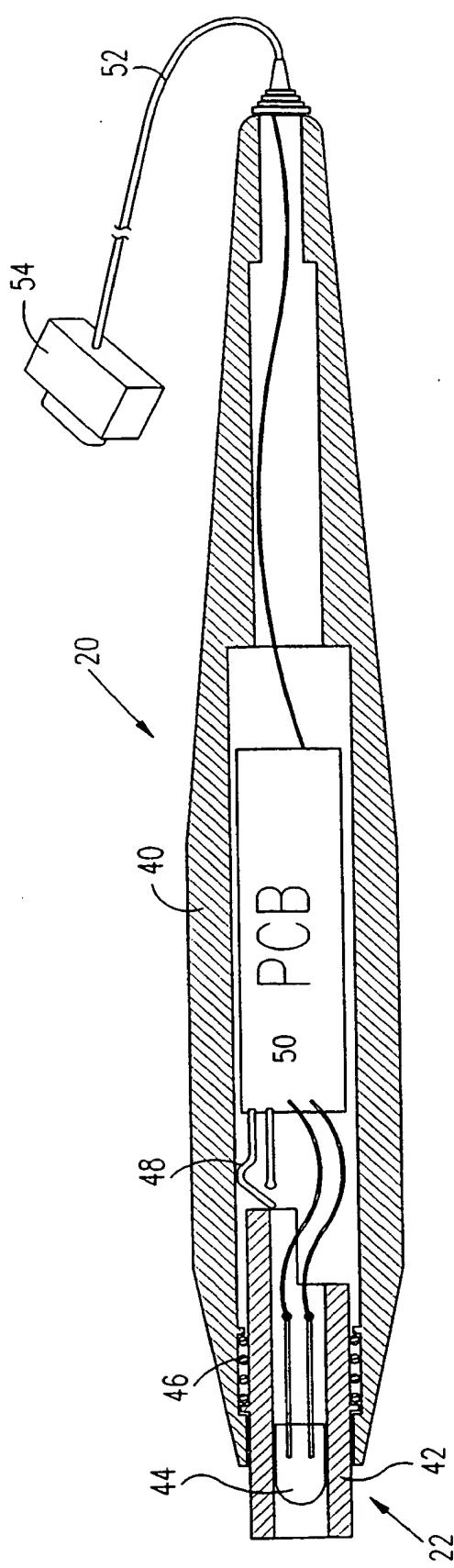


FIG. 3E



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FIG. 4



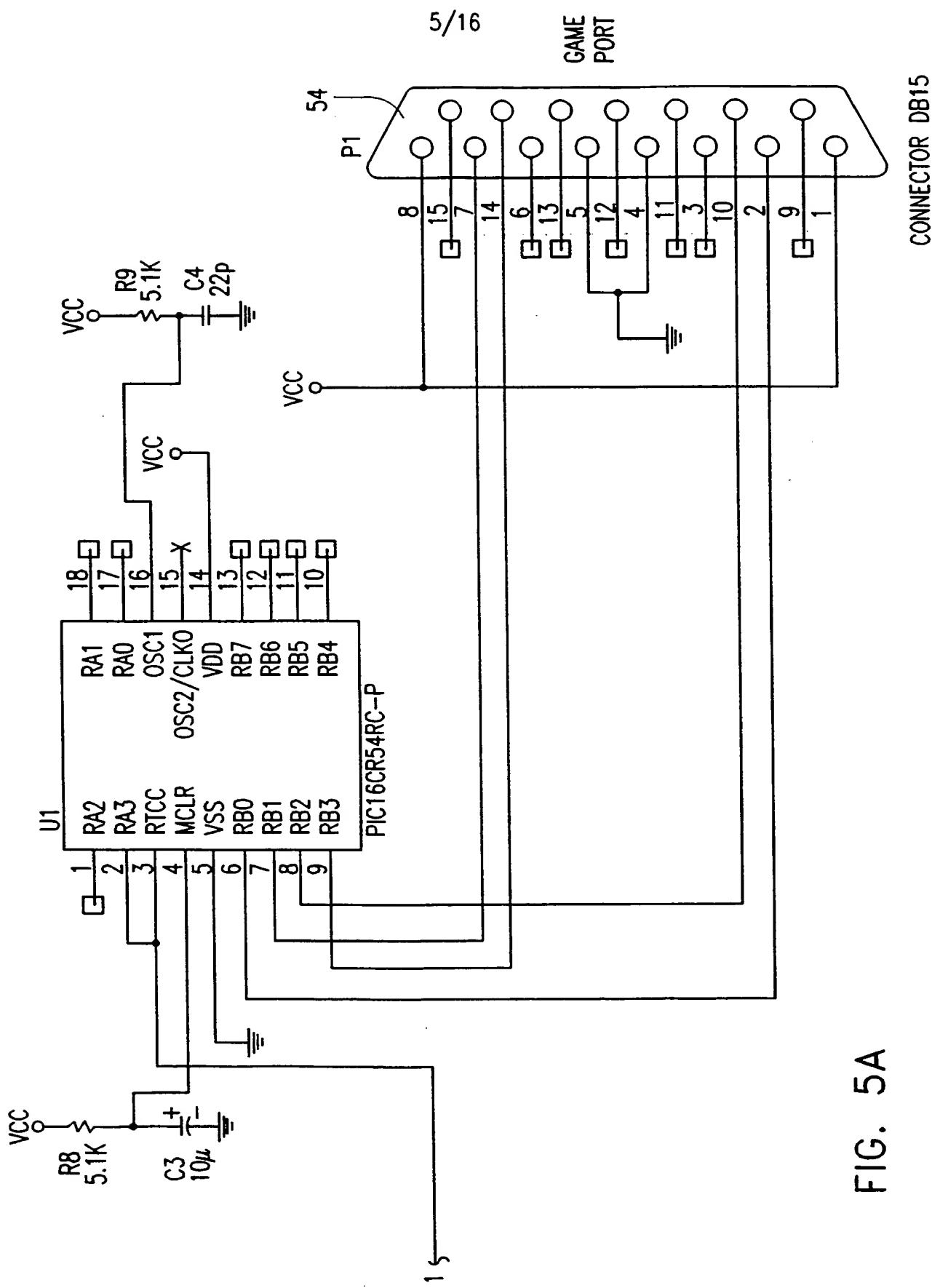
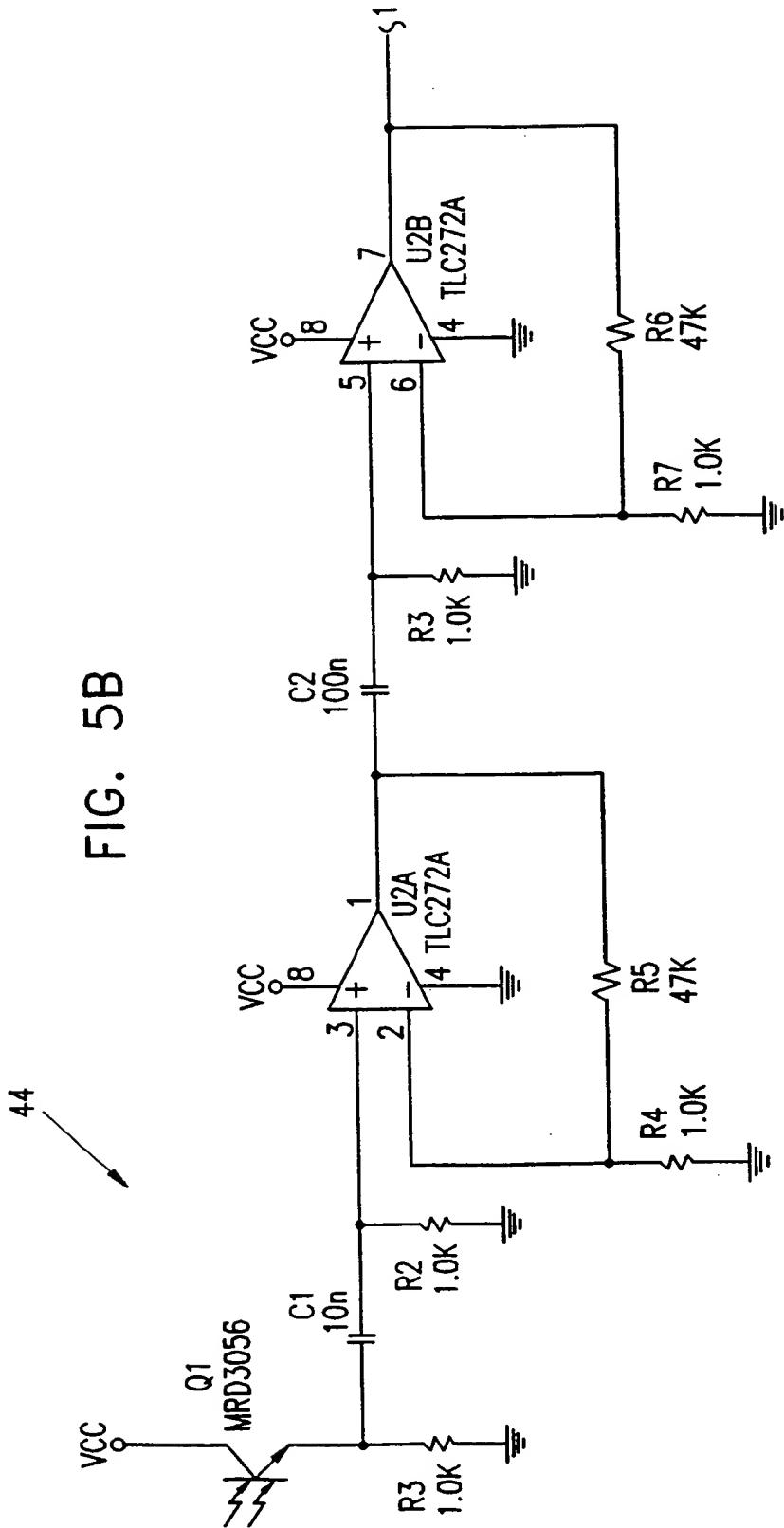


FIG. 5A

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FIG. 5B



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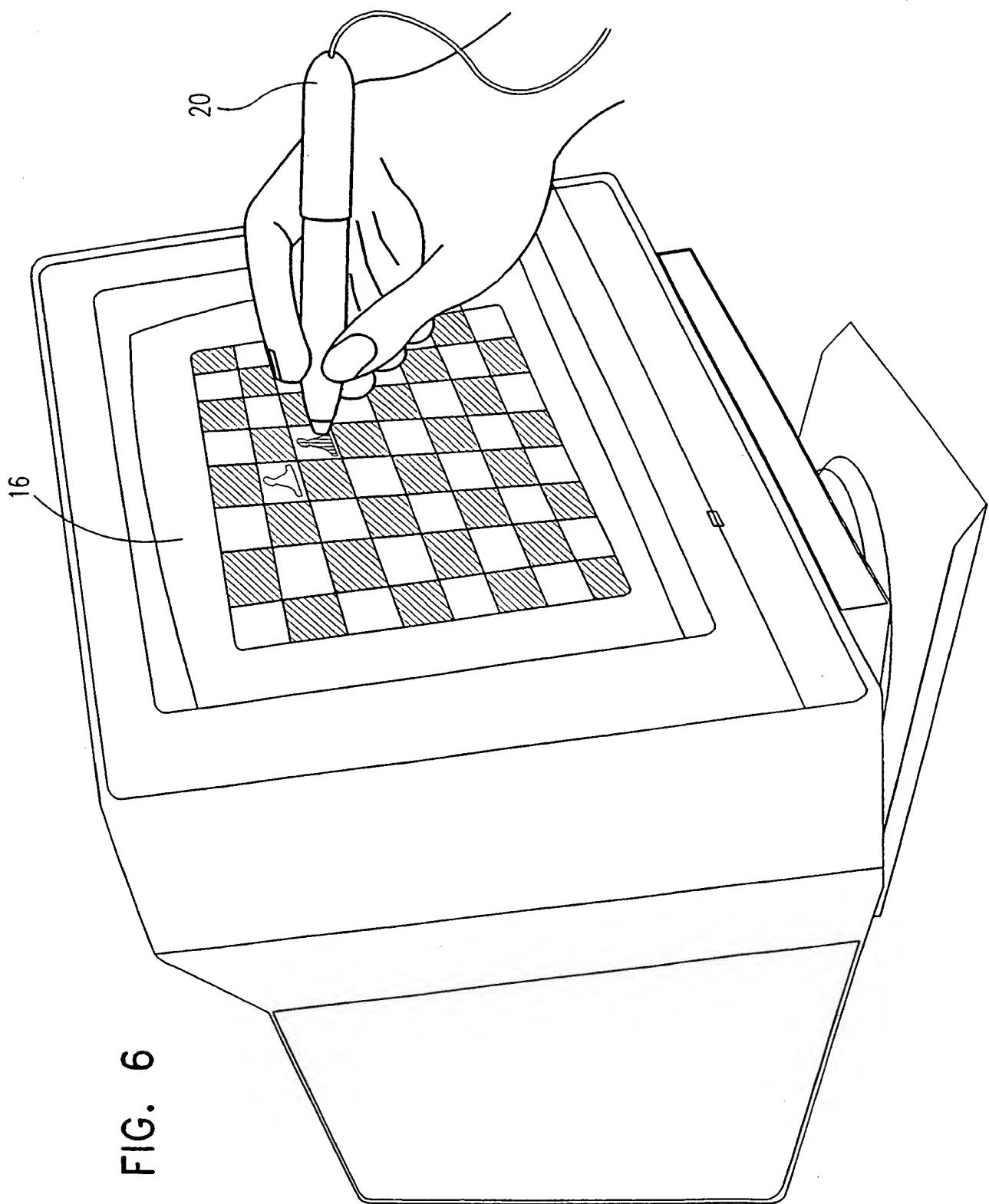


FIG. 6

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FIG. 7C

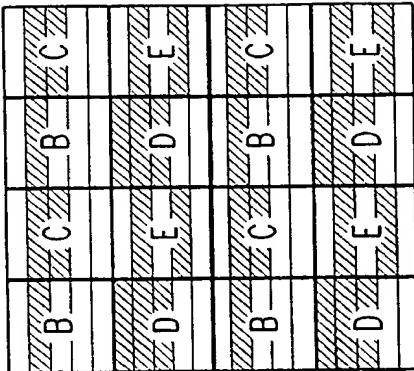


FIG. 7B

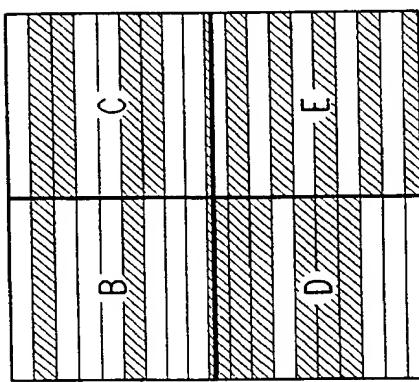


FIG. 7A

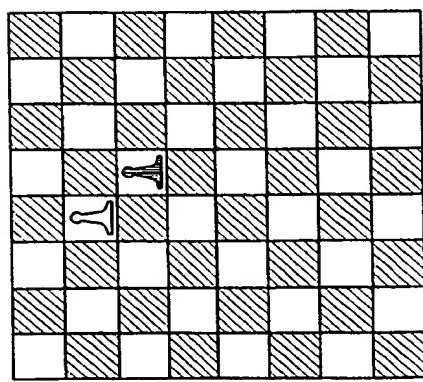


FIG. 7D

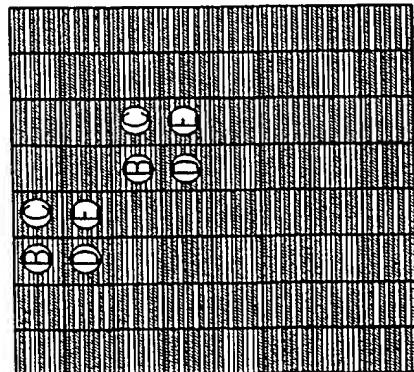


FIG. 7E

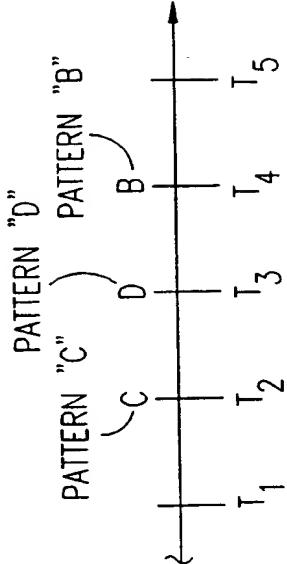
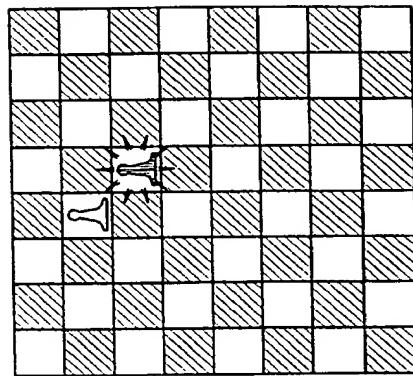
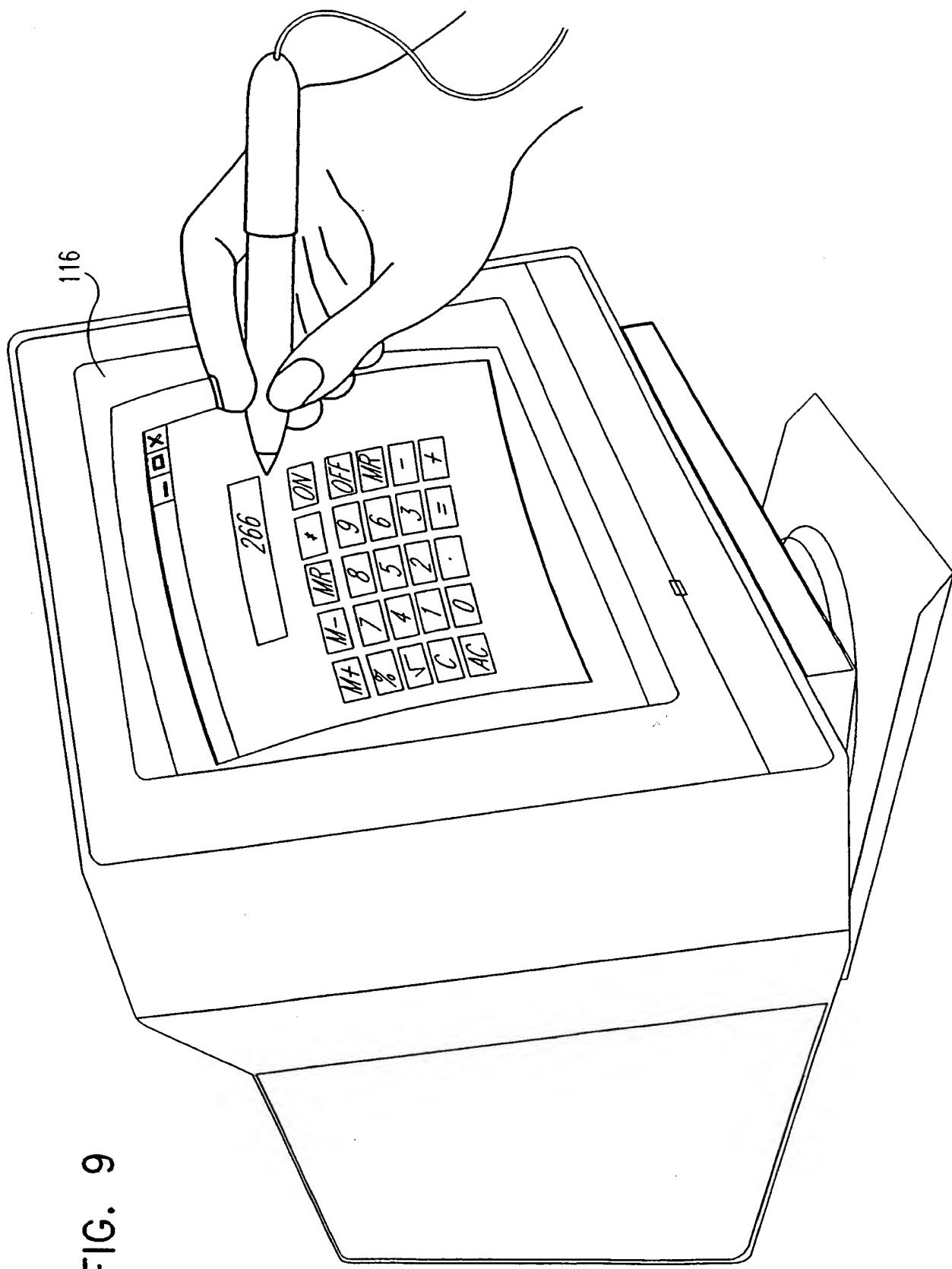


FIG. 8

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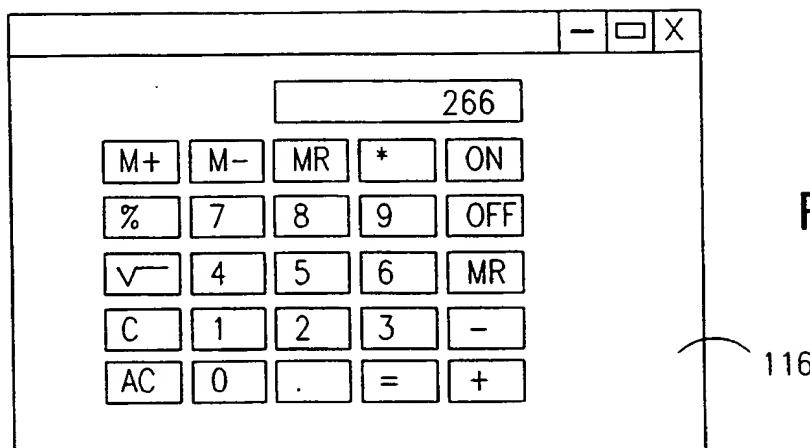


FIG. 10A

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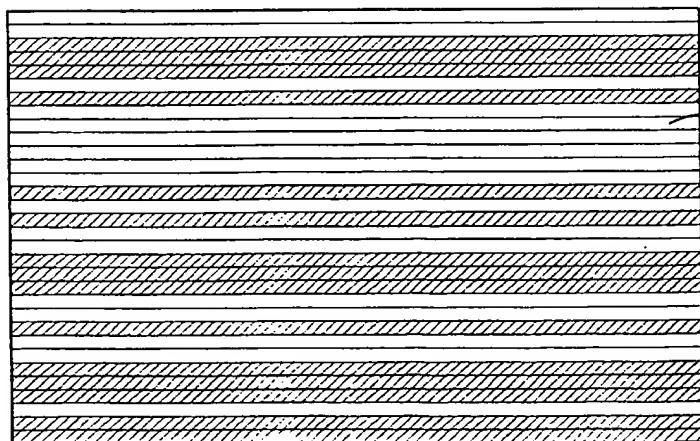


FIG. 10B

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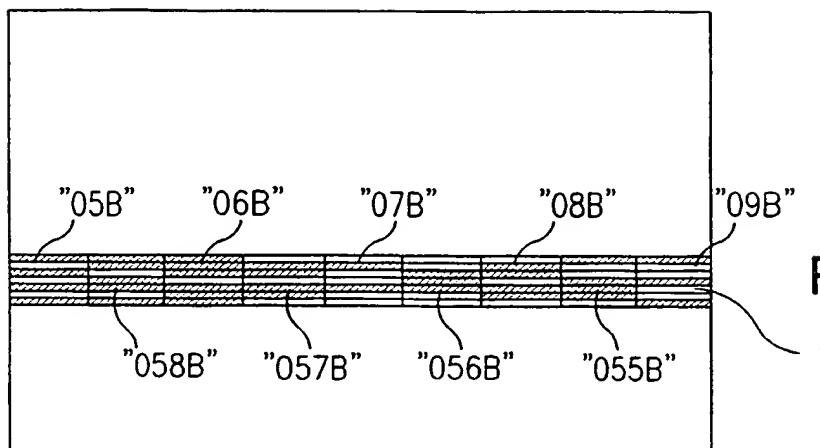


FIG. 10C

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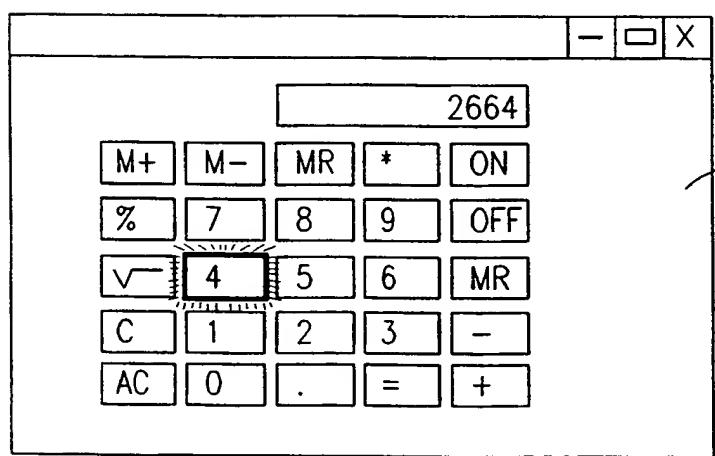


FIG. 10D

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FIG. 11A

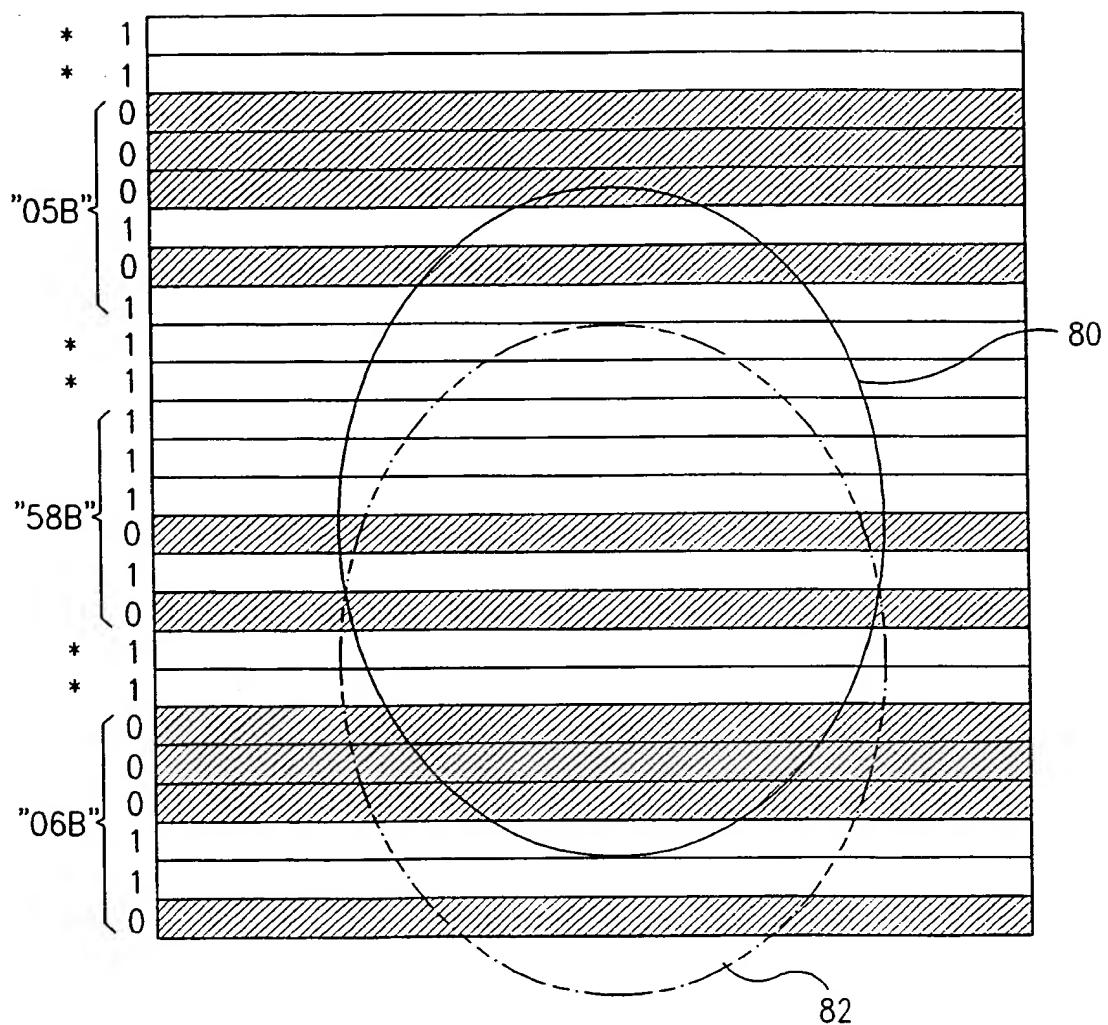


FIG. 11B

FIG.

... 1 0 1 1 1 1 1 1 0 1 0 1 1 0 0 0 1 ...

Y1

"58B"

FIG. 11C

Diagram illustrating a binary sequence. The sequence is represented by a series of bits:  $\dots 1 \ 1 \ 1 \ 1 \ 0 \ 1 \ 0 \ 1 \ 1 \ 0 \ 0 \ 0 \ 1 \ 1 \ 0 \ 1 \dots$ . A bracket under the bits  $1 \ 1 \ 1 \ 1 \ 0$  is labeled "58B". An arrow labeled  $Y_2$  points to the second bit from the right in the sequence, which is a  $1$ .

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FIG. 12

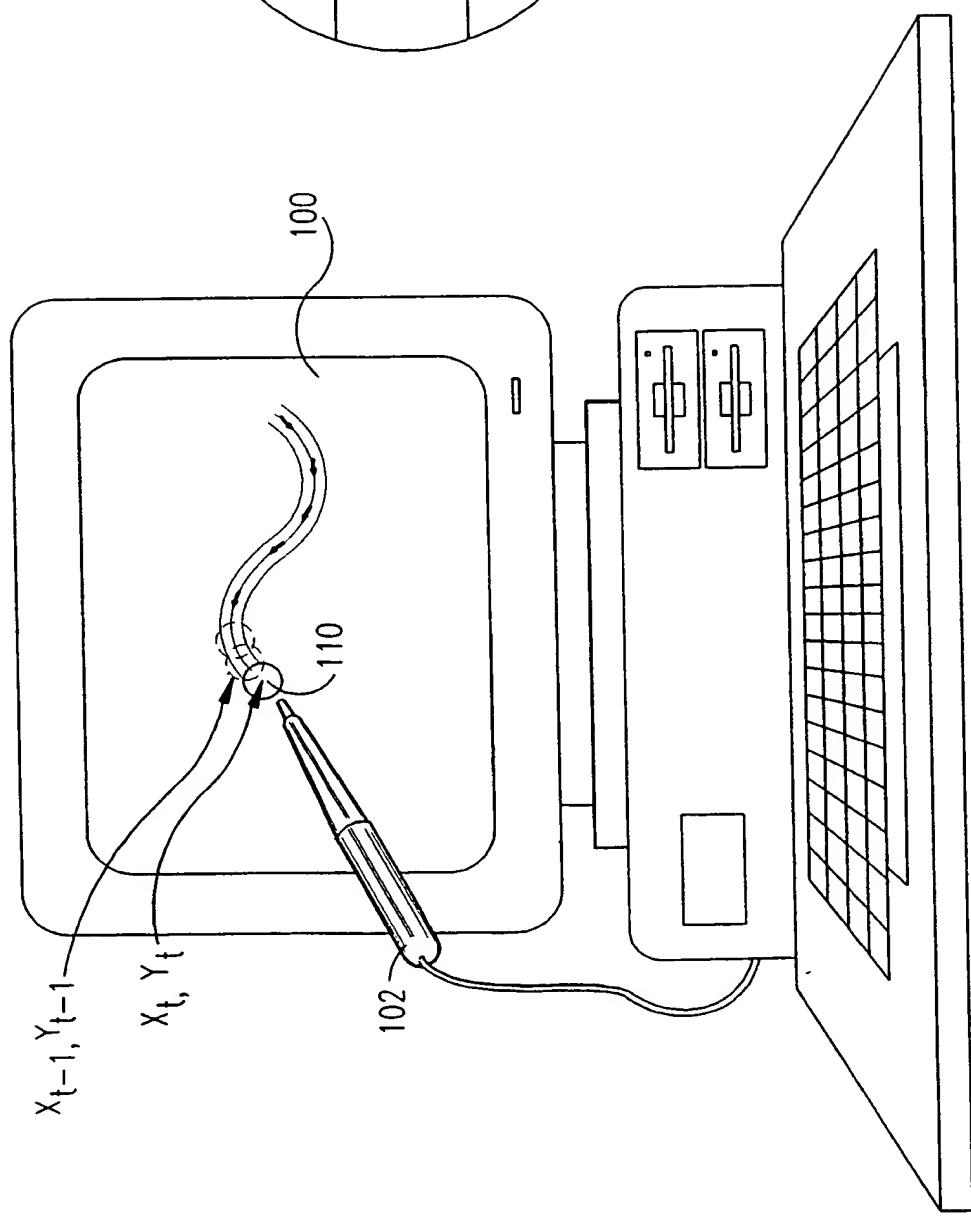
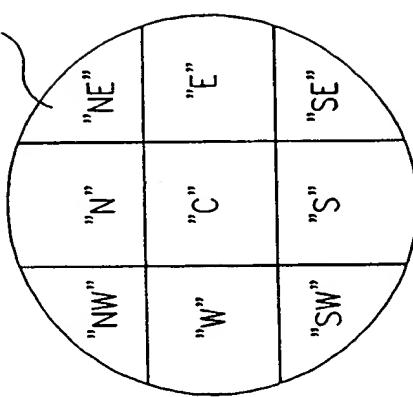
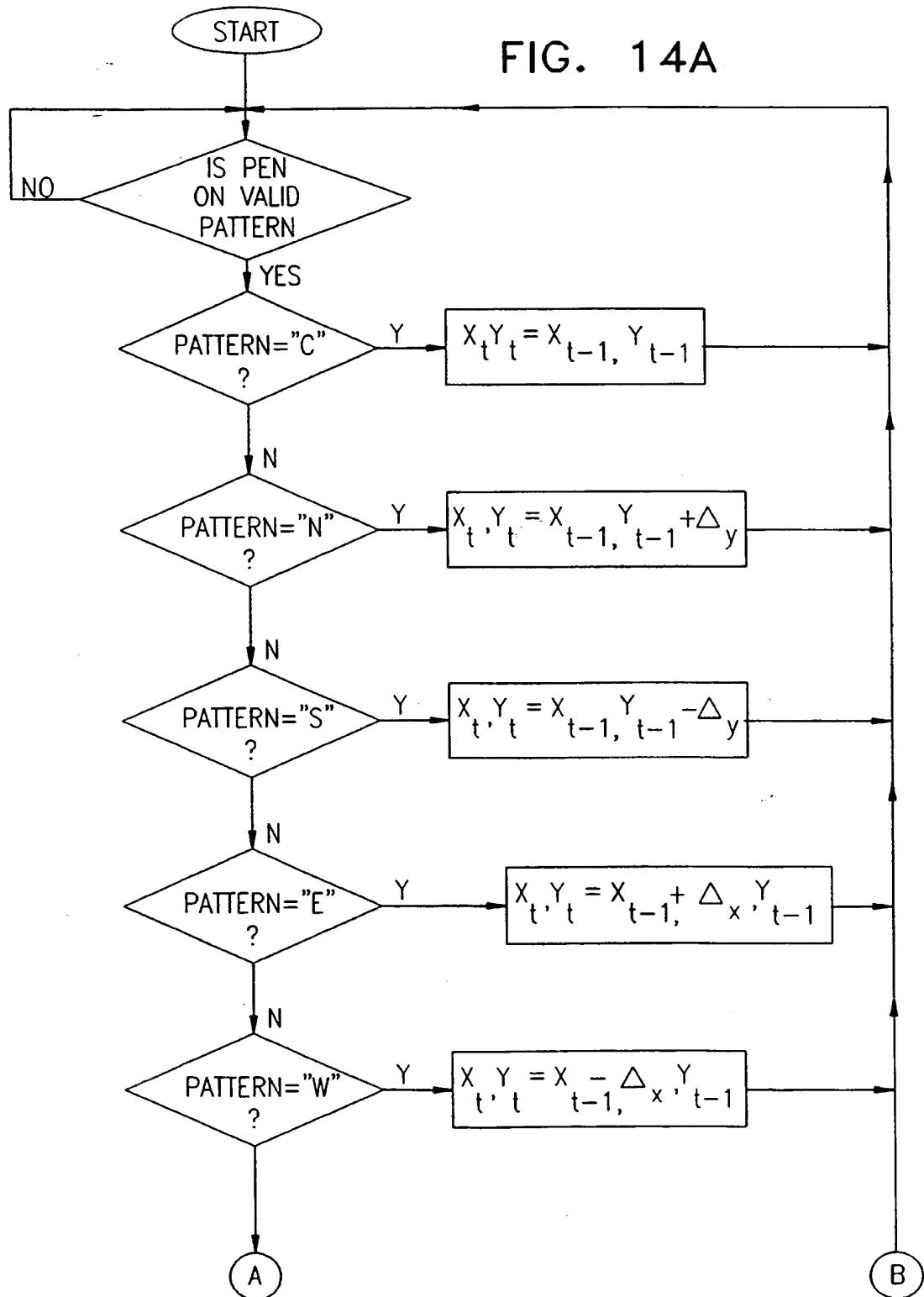


FIG. 13



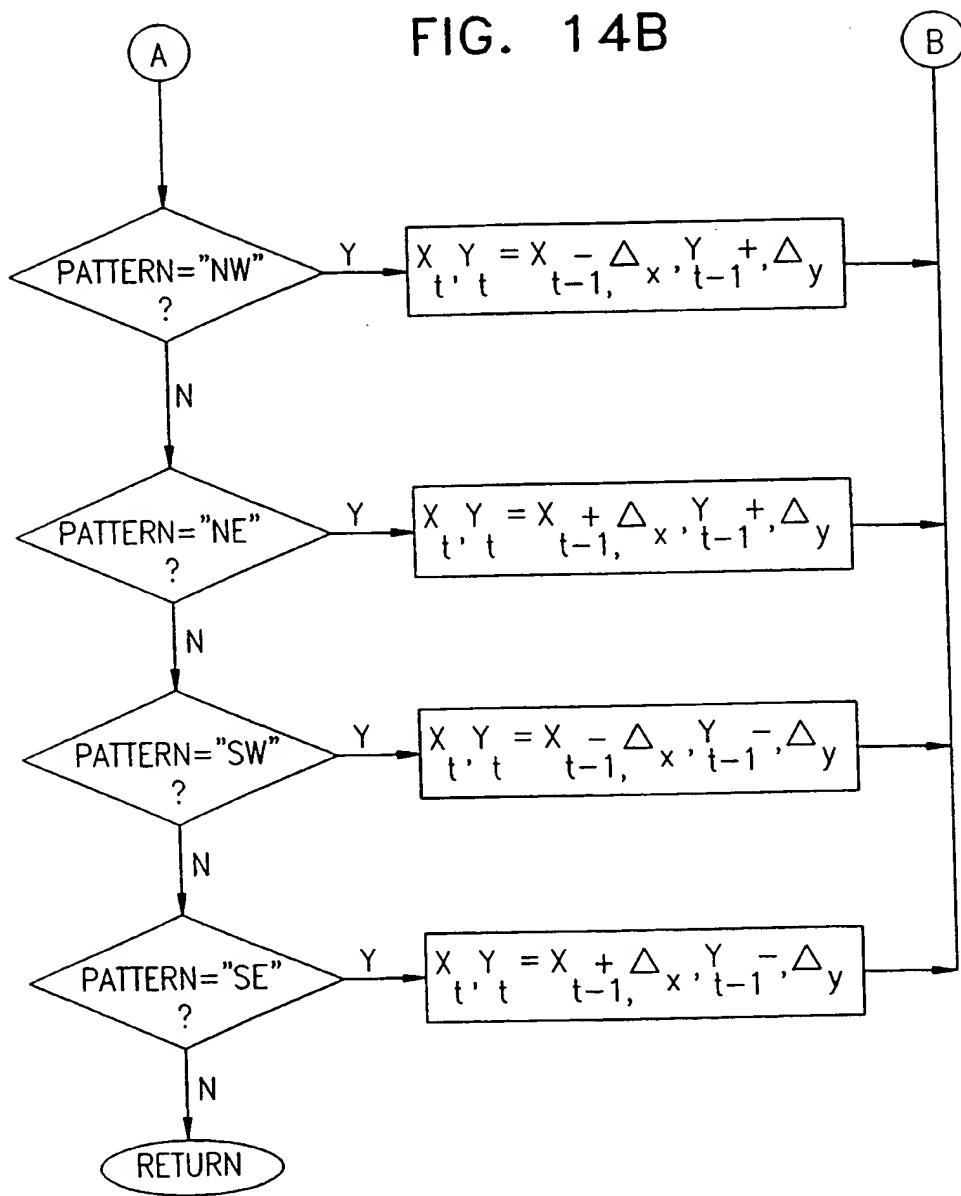
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FIG. 14A

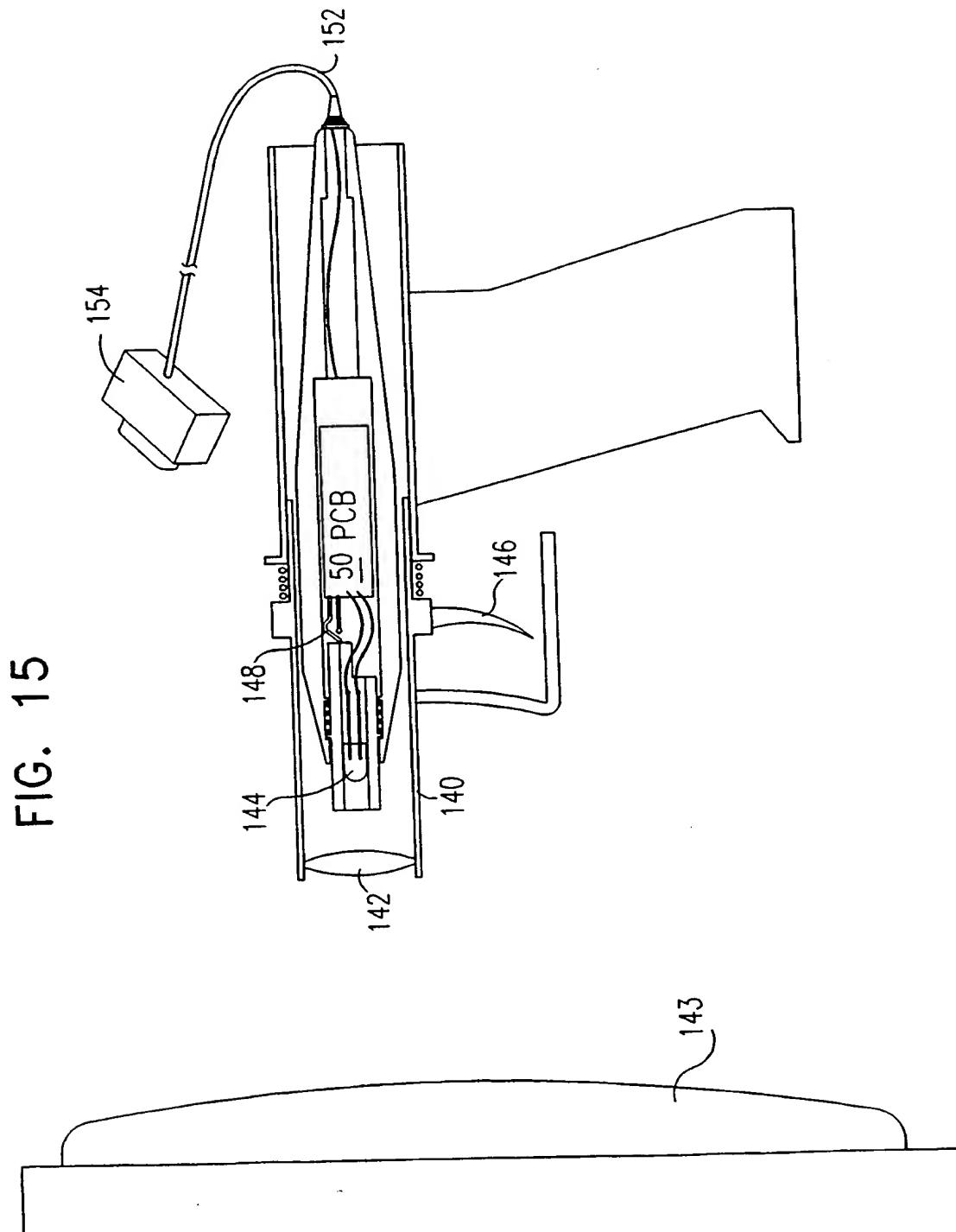


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FIG. 14B



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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/IL97/00404

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : G09G 5/00, 1/00

US CL : 345/179, 180

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 345/179, 180, 181, 182, 173

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS SEARCH TERMS: light pen, display pointer, optical sens?, optical pattern recognition, superimposed, pattern recognition circuitry, CRT, LCD, pointing system, pointing apparatus

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3,832,693 A (ISHIZAKI et al) 27 August 1974, column 3, lines 5-32	1-20
Y	US 4,608,601 A (SHRECK et al) 26 August 1986, column 7, lines 17-36, lines 51-60, column 8, lines 14-19, column 9, lines 34-37	1-20
Y	US 4,999,617 A (UEMURA et al) 12 March 1991, column 1, lines 15-17, column 3, lines 30-31, column 8, lines 65-67, column 9, lines 1-11, lines 23-39, column 11, lines 30-35	1-20

Further documents are listed in the continuation of Box C.

See patent family annex.

Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

12 MAY 1998

Date of mailing of the international search report

09 JUL 1998

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